



## Technology overview



# CHOKES AND CONTROL VALVES

Master Flo Valve Inc. designs and manufactures choke valves and specialty control valves for both surface and subsea applications to the requirements of ISO and API. Our products meet the CE-marking requirements as needed by our customers.

Continual product innovation through extensive research and development demonstrates our commitment to remaining the leader in choke technology. Our test facilities allow us to develop new products that are fully qualified to applicable industry standards. Some examples include:

- **E-Series Valve Design**
- **5CB Tungsten Carbide**
- **Multi-Stage Trim**
- **Metal-to-Metal Seals**
- **High-Temperature Valves to 850°F**
- **Subsea Valves to 18000 ft**
- **Valves for HPHT service**

Master Flo also works in partnership with customers to develop new technology to meet special requirements. Two such examples include:

- the development of the trim set for a **downhole choke**
- the development of a **subsurface gas-lift choke**

## Subsea Chokes

Subsea developments are constantly pushing the technology frontier, which results in the need to continuously improve on existing products. Reliability is of critical concern for subsea choke systems. Three general types of choke systems are available:

### Bolted-Bonnet Style

The choke internals are held in place by a bolted bonnet, so these chokes are not intended to be serviced subsea. They are suitable for modular-retrieval systems or applications where maintenance is not an issue.

### Diver Insert Retrievable

These chokes are intended for water depths that are suitable for diver intervention. They feature a diver-operated clamp mechanism that holds the choke internals in place. Double-tapered metal bonnet seals are used for reliable sealing.

### Insert Retrievable (HRV)

These chokes are qualified for water depths to 18000 feet (5500 meters) and are available for pressures up to 15000 PSIG. The choke internals and actuator are contained as a separate retrievable module that can be installed or retrieved by a cable-deployed tool with the assistance of a remote-operated vehicle (ROV). This module incorporates an ROV-operated bonnet clamp to fasten the insert to the choke body. Metal-to-metal seals are used at all critical sealing areas.

### Subsea Actuation

Subsea valves also require reliable actuators, and the Master Flo Model SL hydraulic stepping actuator has been developed for this purpose. It is compact, lightweight, and durable and has been qualified to water depths of 18000 feet (5500 meters). It incorporates internal pressure- and volume-compensation and features a modular construction that allows for a variety of orientation and interface options.

Research and the commitment to developing technology leads to continuous improvement and reduction in life-cycle costs for clients.

# SURFACE CHOKES AND CONTROL VALVES

## E-Series Valve Range



Master Flo's standard range of E-Series valves includes choke valves (right-angle bodies) and control valves (inline bodies) that share the same internals for a given nominal size. Thus they also share the same design features and benefits.

The tables below summarize the standard valve configurations available. In addition, project-specific and special configurations are also available. Detailed brochures for each valve are available to provide additional information on the various options.

### E-Series Choke Valve and Trim-Selection Guide

NOMINAL VALVE SIZE	STANDARD END CONNECTION SIZES	MAXIMUM PRESSURE RATING		E-SERIES TRIM				MULTISTAGE TRIM		MULTISTAGE HIGH PRESSURE TRIM	
		PSI	kPa	S.S.	STELLITE	5CB	Cv	STELLITE	Cv	STELLITE	Cv
P1E	1", 2"	6000	41 000	E	E	E	14	MS	4	MSHP	3
P2E	2", 2-1/2", 3"	10 000	69 000	E	E	E	27	MS	7	MSHP	6
P25E	2", 2-1/2", 3", 4"	5000	34 000	E	E	E	45	MS	14	MSHP	10
		15 000	103 000								
P3E	3", 4"	6000	41 000	E	E	E	83	MS	25	MSHP	17
		10 000	69 000								
P35E	3", 4", 5", 6"	6000	41 000	E	E	E	129	MS	54	MSHP	35
		15 000	103 000								
P4E	4", 5", 6"	6000	41 000	E	E	E	205	MS	54	MSHP	35
		10 000	69 000								
P5E	5", 6"	6000	41 000	E	E	E	300	MS	77	MSHP	50
		10 000	69 000								
P6E	6", 8"	6000	41 000	E	E	E	400	MS	77	MSHP	50
P8	8", 10"	6000	41 000				700				

Specifications subject to change without notice.  
Other end connections are available on request.

### E-Series Control Valve and Trim-Selection Guide

NOMINAL VALVE SIZE	STANDARD END CONNECTION SIZES	MAXIMUM PRESSURE RATING		E-SERIES TRIM				MULTISTAGE TRIM		MULTISTAGE HIGH PRESSURE TRIM	
		PSI	kPa	S.S.	STELLITE	5CB	Cv	STELLITE	Cv	STELLITE	Cv
C1E	1", 2"	3600	25 000	E	E	E	14	MS	4	MSHP	3
C2E	2", 3"	6000	41 000	E	E	E	27	MS	7	MSHP	6
C25E	2", 3"	3600	25 000	E	E	E	45	MS	14	MSHP	10
C3E	3", 4"	3600	25 000	E	E	E	83	MS	25	MSHP	17
C4E	4", 6"	3600	25 000	E	E	E	205	MS	54	MSHP	35

Specifications subject to change without notice.  
Other end connections are available on request.

# VALVE FEATURES

Micrometer Calibration Head for repeatable trim positioning

Heavy-Duty Thrust Bearings minimize operating torque

Keyed Stem provides non-rotating rising motion

Bushings guide and support valve stem and trim

Pressure-Balanced Trim minimizes stem load

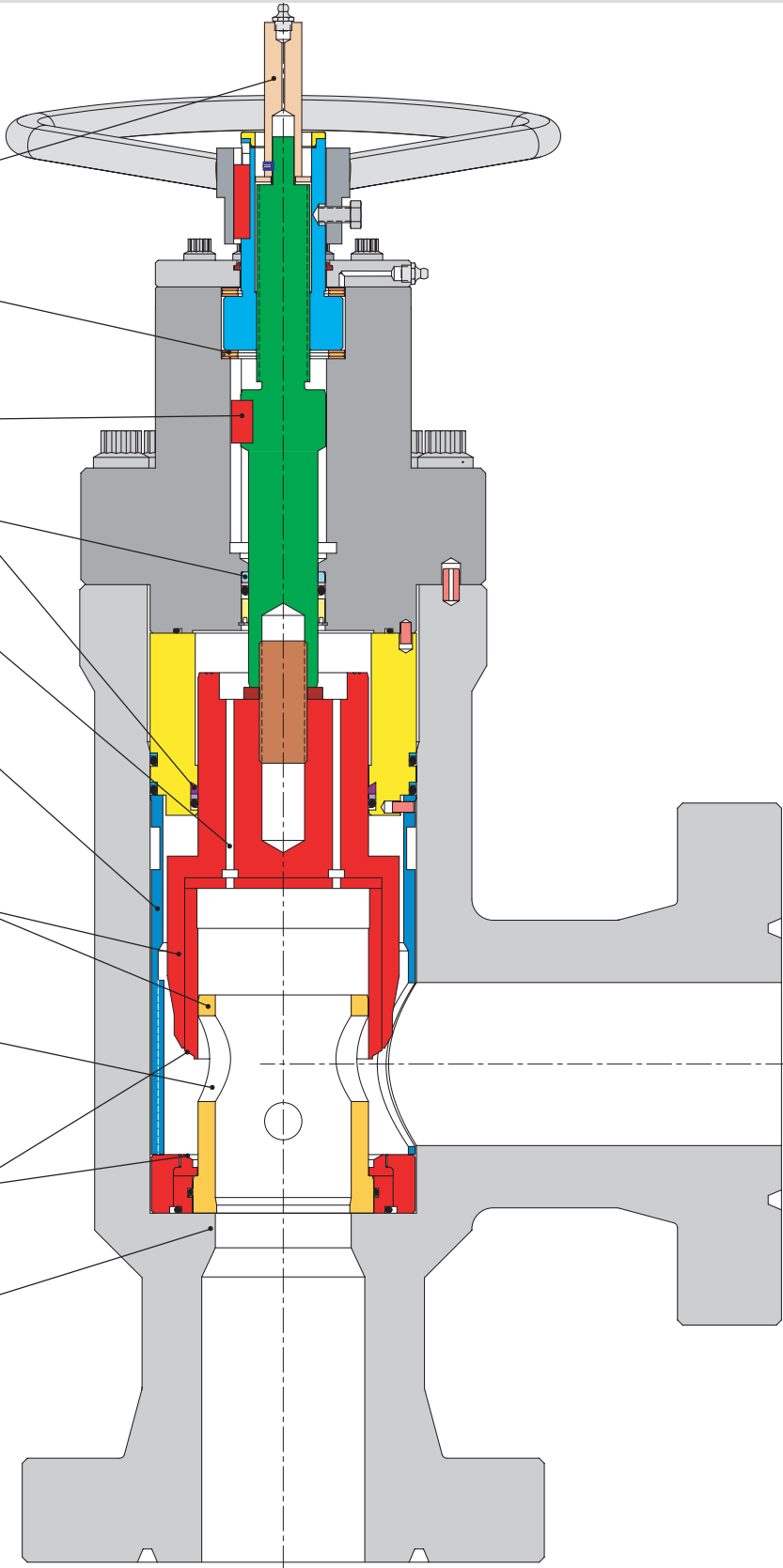
Retaining Sleeve protects valve body, controls annular flow, and retains the seat/nozzle assembly.

Cage with External Sleeve provides long service life

4-Port Equal-Percentage Flow Trim provides superior control

Upstream Independent Shutoff for long sealing integrity

Non-threaded Trim allows for easy servicing

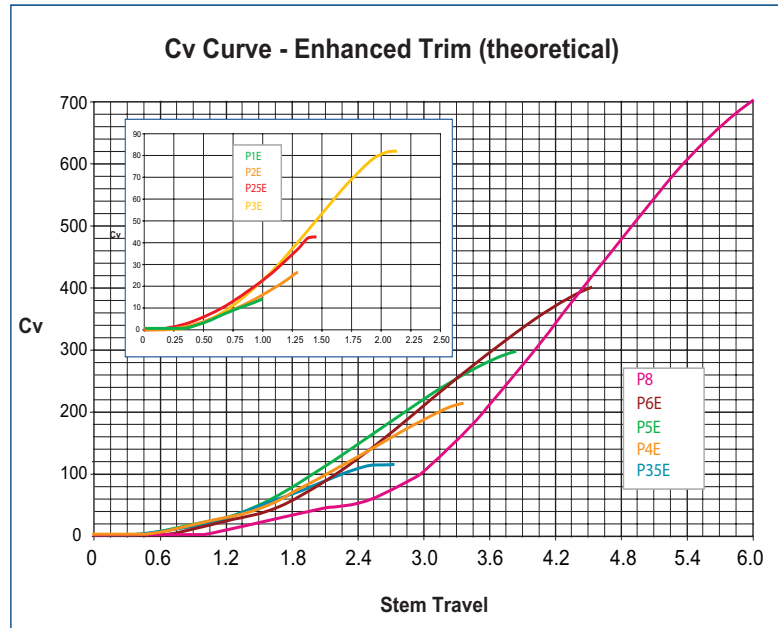


# FLOW CHARACTERISTICS

## C<sub>v</sub> Curve

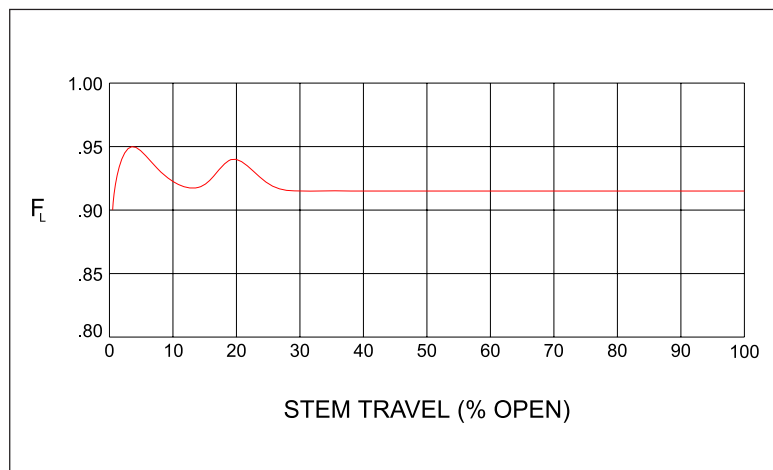
As shown in the C<sub>v</sub> curves, the trim for each valve size provides an **equal-percentage flow characteristic**.

A gradual response in the lower portion allows for controllability near the closed position, and the upper portion shows the overall capacity of the trim. This results in an **exceptionally high turndown ratio** and **maximum controllability**.



## F<sub>L</sub> Pressure Recovery

The tendency for the pressure of a fluid to dip below its final pressure while being throttled is called the vena contracta effect. The magnitude of this dip compared to the inlet and outlet pressures is described by the liquid pressure recovery factor (F<sub>L</sub>). A large F<sub>L</sub> value means a less drastic vena contracta effect, which results in a **decreased cavitation potential**, **lower noise generation**, **increased flow capacity**, and **longer trim life**. The Master Flo trim has been designed with high F<sub>L</sub> values throughout its control range.

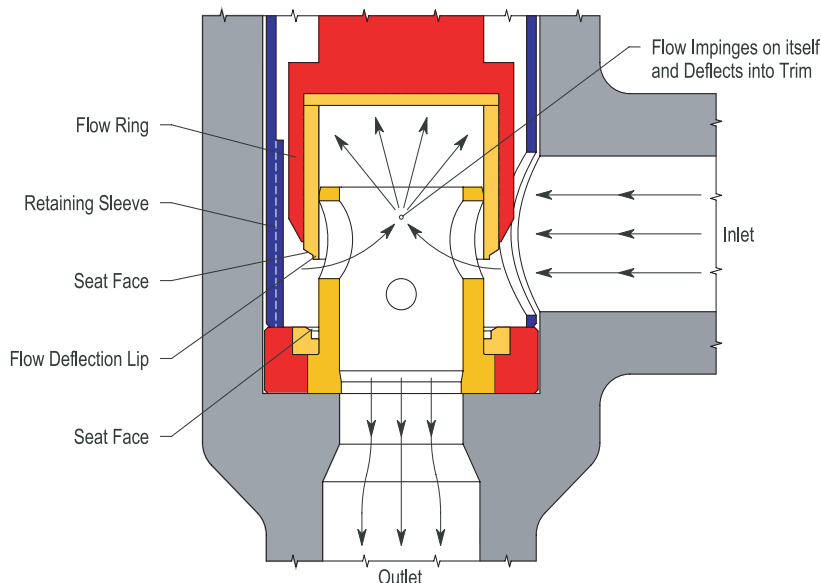




## Trim Design

In 1979, Master Flo introduced the original cage-with-external-sleeve trim design thus setting the standard for choke performance. We have continually raised this standard, and with the development of the E-Series trim in 2001, we have achieved a dramatic improvement in trim life.

The trim consists of a **ported cage** (nozzle) with an **external sliding sleeve** (flow ring), which results in flow that impinges in the center of the nozzle thereby **dissipating the throttling energy** within the process media. The external flow ring also tends to direct the impinging flow upward into the trim away from the outlet; this further dissipates the throttling energy and contains the residual throttling wear within the hardened trim components. The valve body outlet is protected from wear because the throttling energy is dissipated before the flow enters the outlet bore. As well, the retaining sleeve isolates the main body bore from the incoming flow thus further protecting the body from potential wear. Such control and containment of wear makes the Master Flo choke valve ideal for high-pressure, large-pressure-drop, and severe-service applications for both liquids and gases.



## 4-Port Flow Control

The Master Flo standard trim achieves accurate long-life control by using two pairs of ports in the nozzle. The smaller lower ports provide the initial 15% control range while the larger upper ports provide the overall capacity. This produces an equal-percentage flow characteristic that offers maximum control throughout the operating range.

The port configuration incorporates an exceptionally high turndown ratio, which provides a wide control range and excellent versatility.

## Independent Upstream Shutoff

The Master Flo trim is designed to achieve exceptional shutoff throughout its life. The tapered seat faces are positioned upstream from the throttling components so that they are not subjected to throttling wear. Incoming flow is diverted away from the sliding seat face by a flow-deflection lip on the leading edge of the flow ring. A “dead band” between the stationary seat and the nozzle ports ensures that flow is minimal during seating, which further protects the seat faces from wear.

The trim achieves Class V shutoff per FCI 70-2 - 1998. Class VI shutoff is also available with suitable actuation.



## E-Series Development

Master Flo designed and built an in-house erosion test facility to investigate methods for improving valve life. The ensuing research study resulted in the “E-Series” upgrade that was applied across our product line. This upgrade includes design changes that better control the flow dynamics in order to minimize wear and dramatically improve valve life. Importantly, these E-Series upgrades are interchangeable on older valve models.

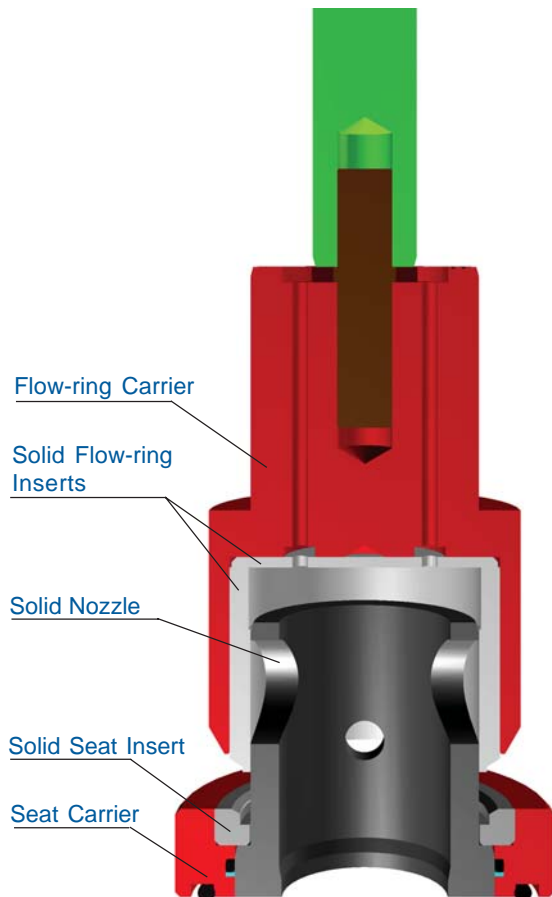
This research also focused on new materials, which led to the development of our proprietary 5CB Tungsten Carbide.

## 5CB Trim Material

Master Flo has developed the proprietary 5CB Tungsten Carbide with a micrograin composite binder. Extensive erosion testing has confirmed that 5CB offers a marked improvement in erosion resistance. This material also has exceptional corrosion resistance and superior toughness.

5CB Tungsten Carbide is a premium material suitable for all service conditions and especially for high-velocity or erosive applications. All 5CB trim components are manufactured from solid (rather than coated) parts, which further enhances the trim life.

Together with the E-Series enhancements, 5CB sets a new standard in choke performance.



Closed Trim

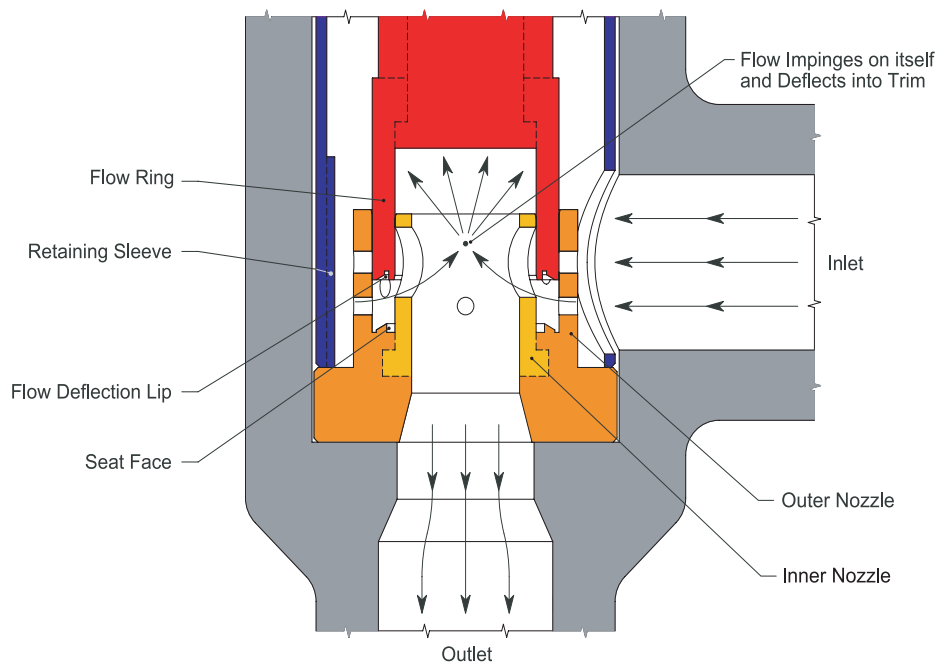
# STANDARD VALVE TRIM

## Multi-Stage Trim

For liquid-flow applications with large pressure drops, Master Flo has multi-stage trims available that throttle the pressure in two separate stages. These trims consist of two concentric ported cages with an intermediate sliding sleeve, and the inner cage (nozzle) has the same port configuration as the standard trim. As in the standard trim, seating integrity is maintained throughout the life of the trim.

By splitting the overall pressure drop into two smaller ones, the pressures at the vena contracta are prevented from dipping as low as in a single-stage trim. Through this, the potential for cavitation and its associated erosion and noise are also reduced. Two variations on this design are available; the MS trim splits the pressure drop in a 1:1 ratio, and the MSHP trim splits the pressure drop in a 4:1 ratio. Thus the MSHP trim is suitable for larger overall pressure differentials than the MS trim.

Multi-stage trims are available only in Stellite 6® material.



## High-Capacity Trim

Master Flo has developed a high- $C_v$  trim for low pressure differentials enabling higher flow capacity for a given valve size. This trim is intended for mature applications that have no entrained abrasives and as such is subject to review of the service conditions by Master Flo to determine the suitability for use.

This trim is intended as a retrofit, so it uses the same parts as the standard trim except for the high- $C_v$  nozzle, which has more ports than the standard nozzle. High-capacity trim is available in stainless steel or tungsten carbide for most valve sizes.

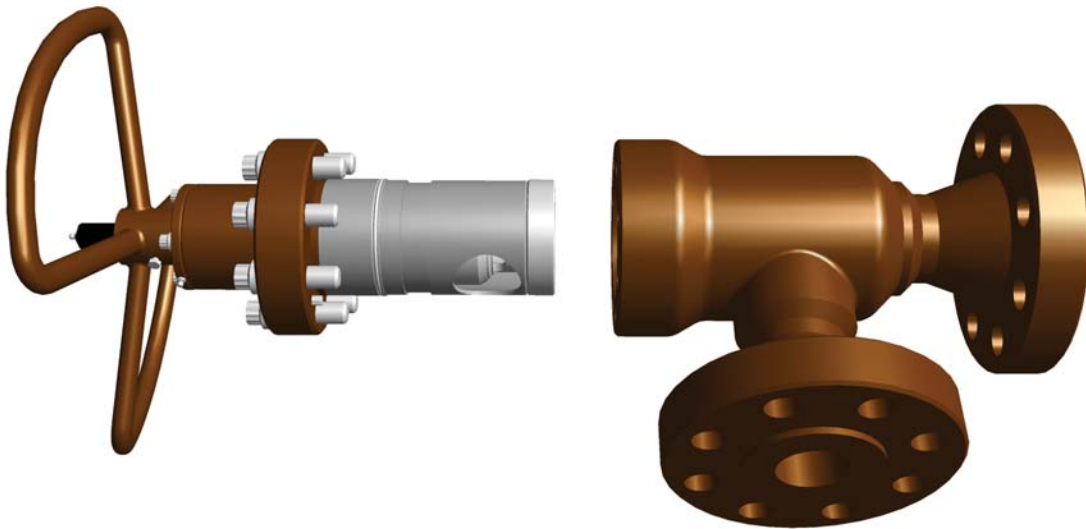


## OTHER FEATURES

### Trim Retention

The stationary trim components are held in place by a retaining sleeve that allows these parts to be **easily aligned** with the flow ring during valve assembly. With the trim mechanically retained rather than threaded into the valve body, all of the valve internals can be removed from the body as a unit without the need for special tools thereby ensuring **ease of service and inspection**. Once the bonnet has been released from the valve body, the entire “choke cylinder” (including all internals as well as the actuator, if applicable) is free to be removed.

The retaining sleeve also functions to control the flow of the process media in the annular volume around the trim. It isolates the valve-body bore from the flow and directs the flow to the nozzle ports. Through extensive erosion testing, the design of the retaining sleeve has **been optimized to extend valve life**.



### Calibration Head

Manually operated valves are supplied with a linear position indicator called a calibration head. This indicator has a square cross section, so it can have a different scale on each of its four faces. This ensures that the valve position can be monitored in the desired units including  $C_v$ , bean size, stem travel, or number of turns (micrometer scale).

The standard scale is the “micrometer” scale, which indicates position by the number of turns of the handwheel. It is read similar to a micrometer caliper by using graduations on the stem nut to achieve a resolution of 1/10 of a turn. This provides **exceptional repeatability** in valve positioning.



## OTHER OPTIONS



### HPHT Service

High-pressure/high-temperature reservoir conditions require careful design and material selection for pressure-retaining components and seals. Master Flo currently has valves suitable for pressures to 15000 PSIG and temperatures to 350°F. Continuing research and development activities are further expanding Master Flo's capabilities in this area.

### High-Pressure Service

Valves suitable for pressures up to 10000 or 15000 PSIG with temperatures limited to 250°F are available in a variety of sizes.

### High-Temperature Service

Valves designed for high-temperature service are available in a variety of sizes. Temperature ratings up to 800°F and pressures to 6000 PSIG can be accommodated in either manual or automated operation. These valves are used in a variety of high-temperature applications including steam injection and SAGD.

### Low-Temperature Service

Valves suitable for service temperatures as low as -150°F are available. The use of appropriate materials is critical in such applications.

### High-Corrosion Applications

For applications that are highly corrosive and require superior materials, valves are available in API-6A material class HH.

### High-Erosion Applications

For flow conditions that result in severe erosion, Master Flo has custom-designed chokes available that reduce valve wear.

### Stem-Lock Mechanism

For manually operated valves, an optional stem-lock mechanism is available to lock the trim in any position.



# ACTUATION AND CONTROL

Master Flo manufactures a range of actuators to complement the choke and control valve product lines. These include linear hydraulic or pneumatic piston and rotary hydraulic or pneumatic stepping actuators. Manually operated valves may be field converted to automated actuation.

Our actuators have the following features:

▶ **Compact  
Direct Drive**



hydraulic

▶ **Robust  
No Open Yokes**



stepping

▶ **High Performance**



pneumatic

## Other Actuators

Various commercial actuators may also be mounted on Master Flo valves. These include:

- single- and three-phase electric
- low-voltage electric
- pneumatic diaphragm
- electro-hydraulic actuators

## Control Options

Actuator controls are available with the following features:

- 3-15 PSI
- 4-20mA
- Fieldbus
- HART protocol



**The Leader in Choke Technology**

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